Biogas Research on Rubber Industry at Prince of Songkla University

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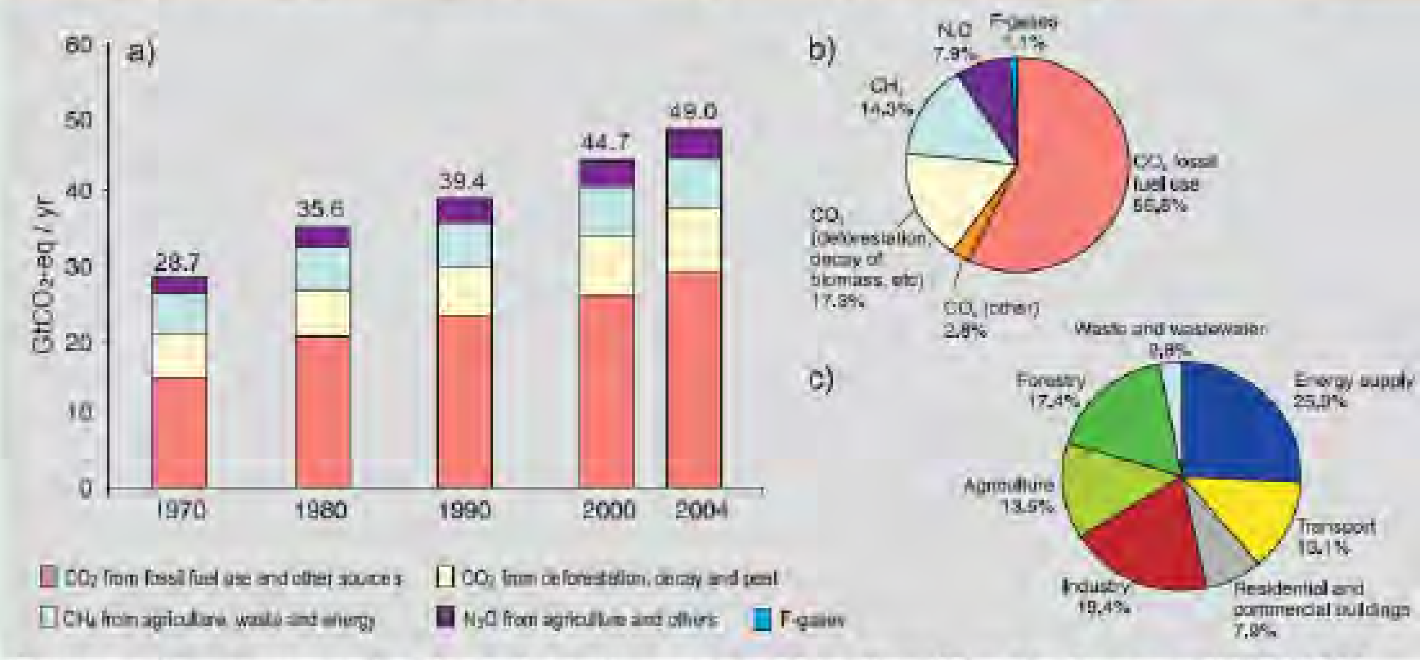
Current situation of electricity generation

Global anthropogenic GHG emissions / Fuels for electricity generation

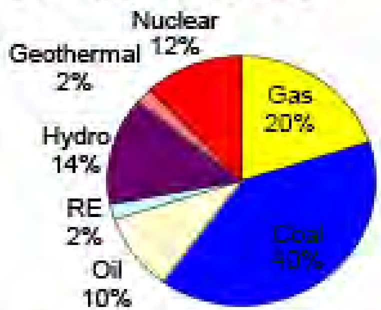
- **More than 56% of GHG emission worldwide are from electricity and heating generation (IPCC 2007)**



Source : An Assessment of the Intergovernmental Panel on Climate Change ,IPCC 2007

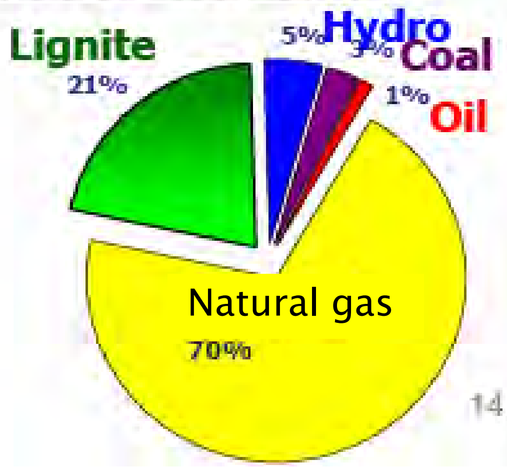
- **Fossil fuels are the main reason for GHG emission. Therefore, alternative and renewable energy are important.**

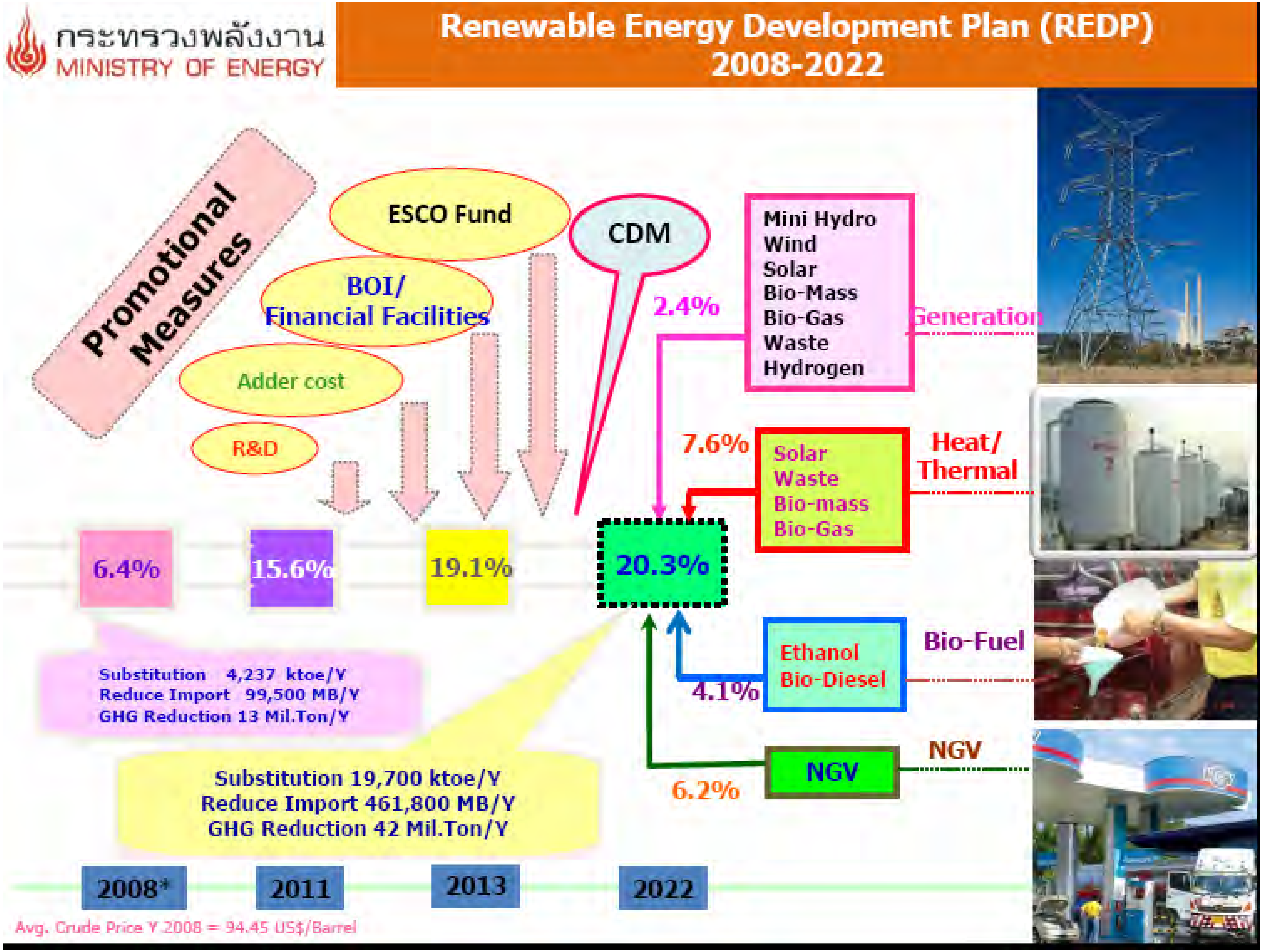
World situation



Source : World Energy Outlook, IEA 2007

Thailand situation





กระทรวงพลังงาน
MINISTRY OF ENERGY
Renewable Energy Development Plan (REDP) 2008-2022
Promotional Measures
ESCO Fund
CDM
BOI/ Financial Facilities
Adder cost
R&D
2.4%
Mini Hydro
Wind
Solar
Bio-Mass
Bio-Gas
Waste
Hydrogen
Generation
7.6%
Solar
Waste
Bio-mass
Bio-Gas
Heat/ Thermal
6.4%
15.6%
19.1%
20.3%
Ethanol
Bio-Diesel
Bio-Fuel
4.1%
NGV
NGV
6.2%
Substitution 4,237 ktoe/Y
Reduce Import 99,500 MB/Y
GHG Reduction 13 Mil.Ton/Y
Substitution 19,700 ktoe/Y
Reduce Import 461,800 MB/Y
GHG Reduction 42 Mil.Ton/Y
2008*
2011
2013
2022
Avg. Crude Price Y.2008 = 94.45 US$/Barrel

กระทรวงพลังงาน
MINISTRY OF ENERGY

Renewable Energy Development Plan (REDP) 2008-2022

Electricity	Current (MW)	2008-2011	2012-2016	2017-2022	Total	%
Mini-Hydro	67	165	281	324		
Wind	5.13	115	375	800		
Solar	38.6	55	95	500		
Bio-Mass	1,644	2,800	3,220	3,700	5,608	2.4%
Bio-Gas	79.6	60	90	120		
Waste	5.6	78	130	160		
Hydrogen	-	0	0	3.5		
Heat/Thermal	Current (ktoe)					
Solar	0.5	5	17.5	38		
Waste	1.09	15	24	35	7,433	7.6%
Bio-Mass	3,071	3,660	5,000	6,760		
Bio-Gas	201	470	540	600		
Bio-Fuel	Current (M.Ltr /Day)					
Ethanol	1.2	3.00	6.20	9.00	9.00	4.1%
Bio-Diesel	1.6	3.00	3.64	4.50	4.50	
Nat. Gas	Current (M. cu.f/Day)					
NGV	147	3,469	5,260	6,090	690	6.2%
						20.3%

As of September 2552

Wastewater in factories

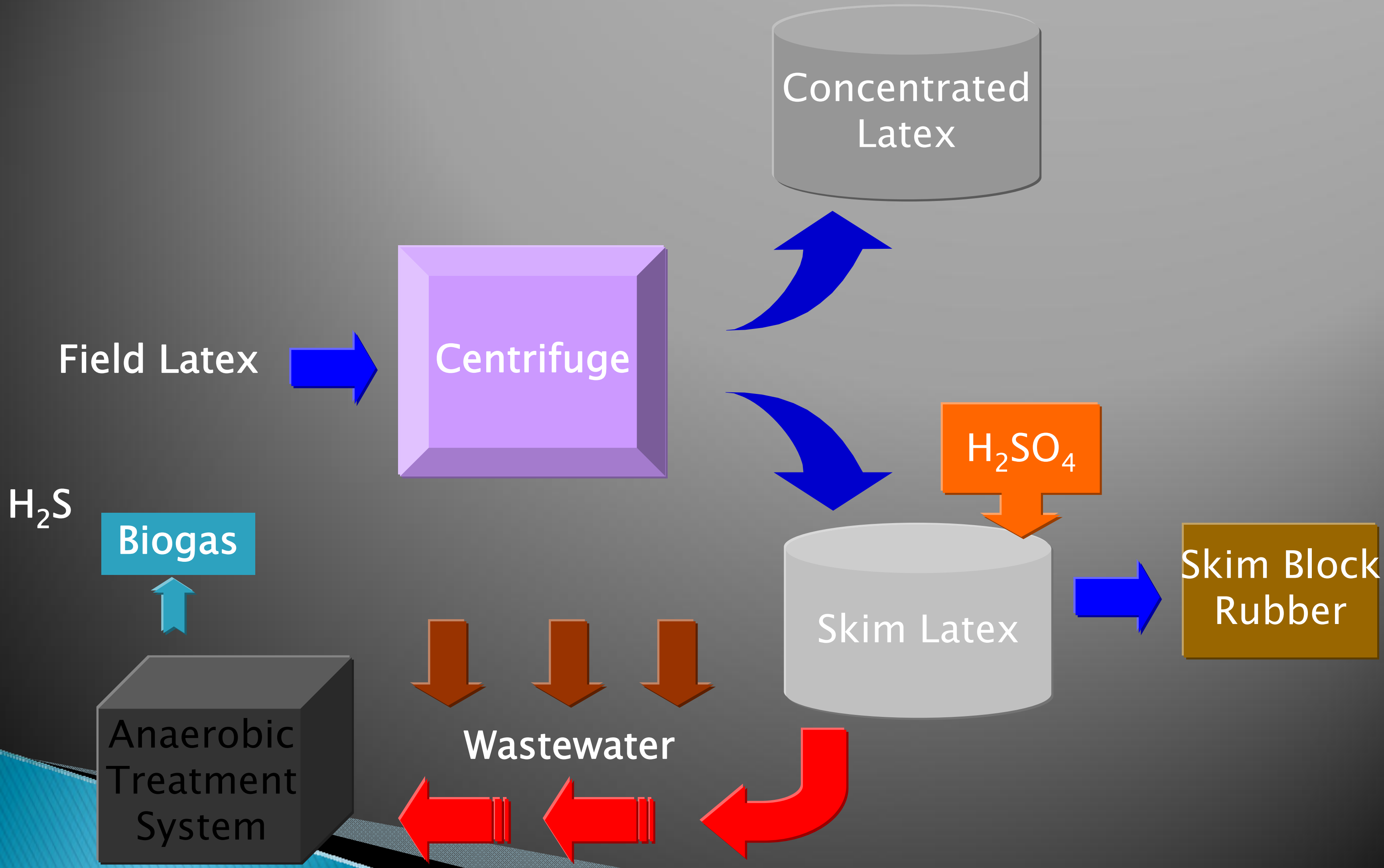



Primary Focus

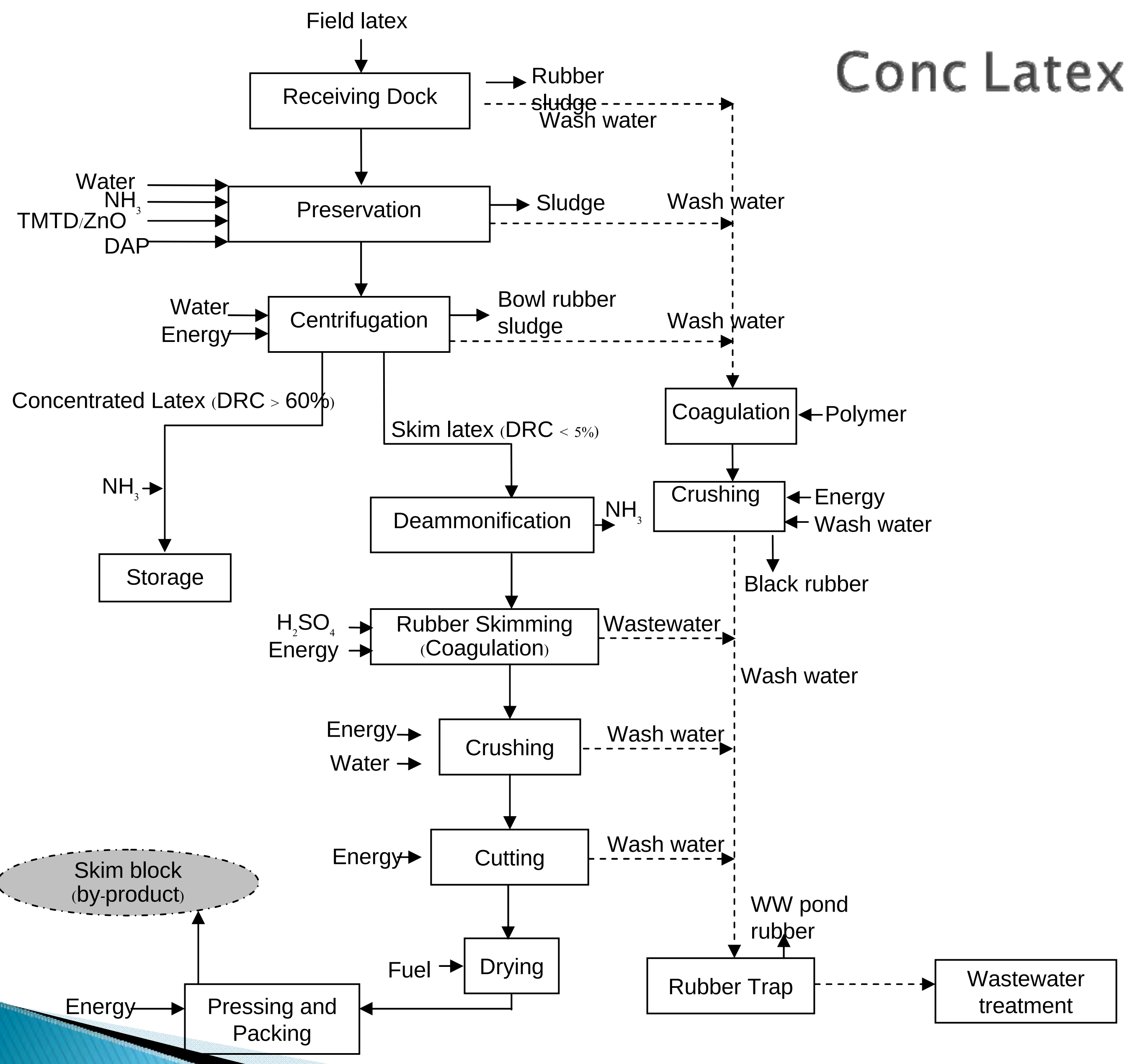
- Waste to Energy
- Major industries in southern Thailand
  - Concentrated rubber latex
  - Palm oil mill
  - Seafood processing
- Emergent opportunity
  - Co-digestion
  - Agricultural residues
  - Municipal solid waste
- No prior established research facility

Major rubber products

Concentrated Latex Production



Conc Latex Production




20.02.2007

23.09.2006



23.09.2006

03.02.2007

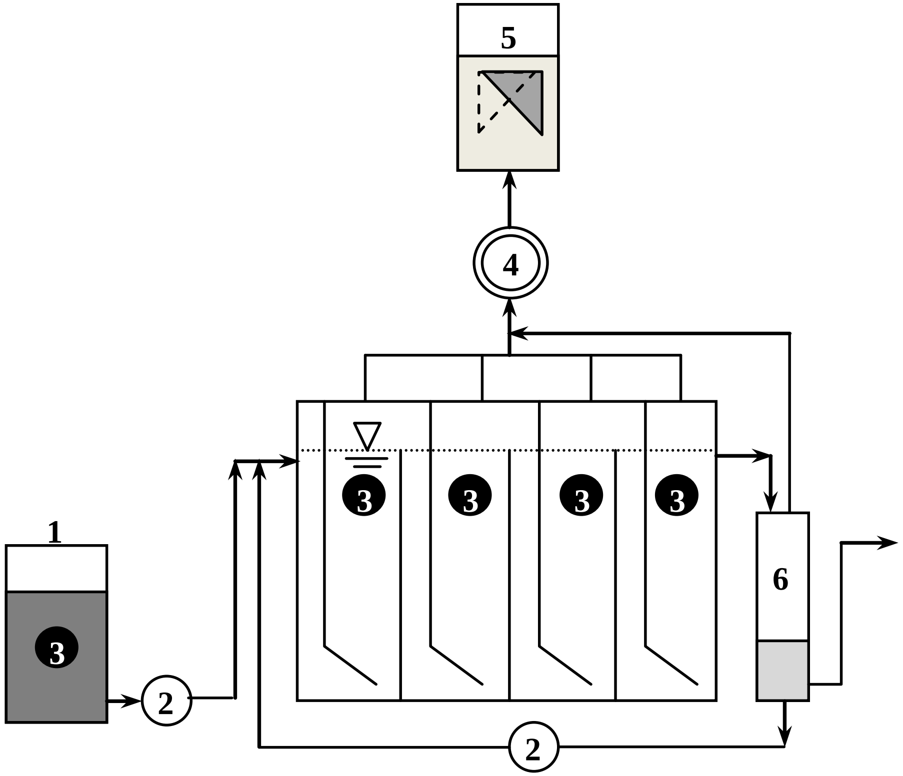

Concentrated Rubber Latex Industry

- High sulfate wastewater 1,000–2,000 mg/L causing H_2S in biogas
- Acidic wastewater pH 4–5
- Biogas technology is not yet wide spread in conc. rubber industry
- Biogas can not be directly utilized
- Low amount of biogas generated 1 m^3:1 m^3

Research for conc latex industry

- Anaerobic treatment of high sulfate ww
- Enhancement of sufidogenesis for sulfate pretreatment
- Cleaner production in conc. latex industry
- Novel polymer for sulfuric acid substitution
- Biological H_2S removal
- Chemical H_2S and CO_2 removal (catalytic and chelate)

1. ABR on conc. latex wastewater



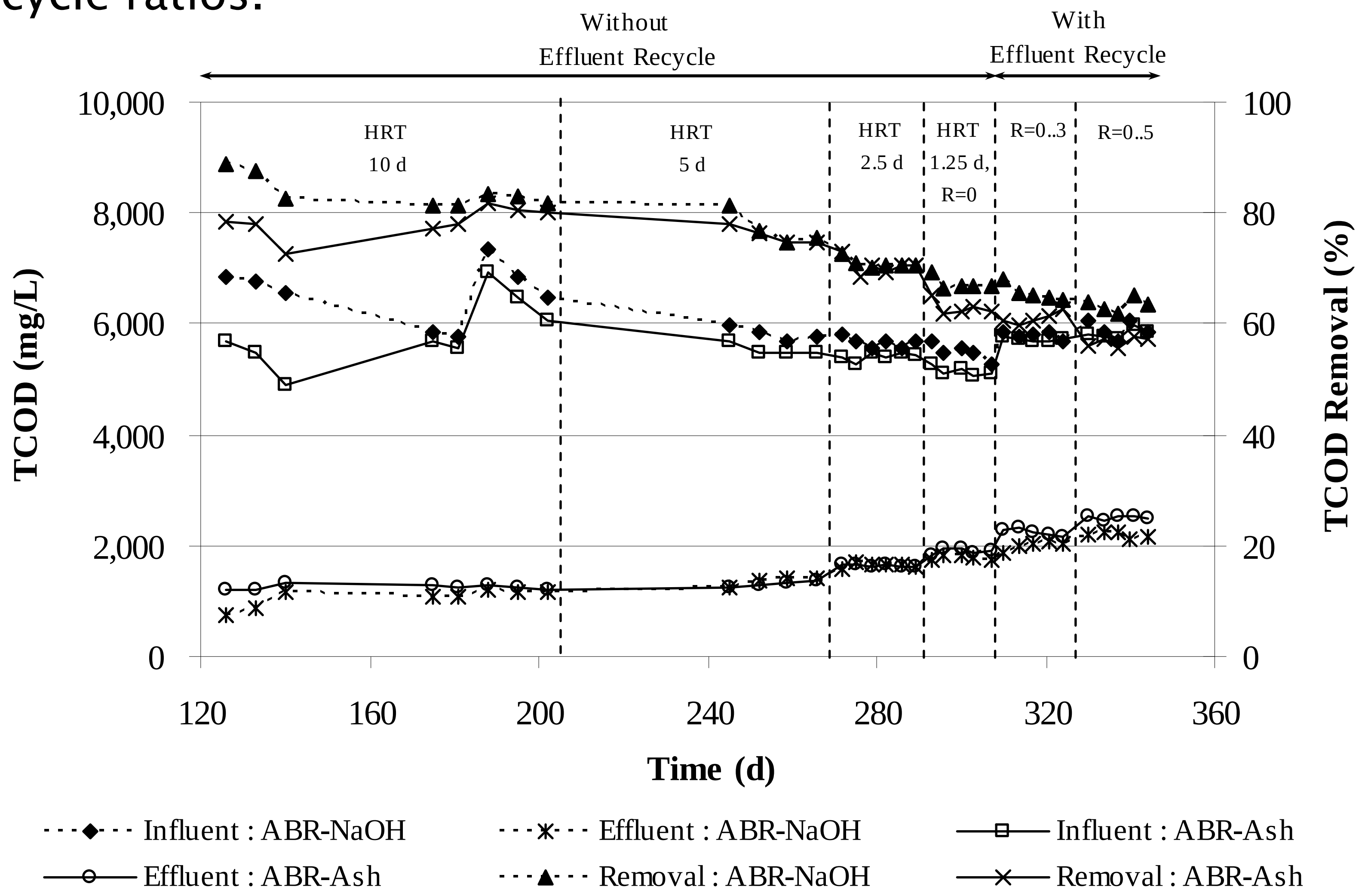
Effluent Recycle

1 = Influent for ABR
2 = Peristaltic pump
3 = Sampling ports
4 = Balloon
5 = Gas collector
6 = Holding tank

Characteristics of raw concentrated rubber latex wastewater and the pH adjusted influent by parawood ash and NaOH to 7.6±0.1

Parameter	Raw wastewater	Influent-NaOH	Influent-Ash
Temperature (^{O}C)	27.7±4.6	24.7±2.7	25.6±2.4
pH	4.73±0.82	7.58±0.1	7.58±0.1
Alkalinity (mg/L as $CaCO_3$)	358±24	1,859±167	2,022±224
Volatile Fatty Acids (mg/L as CH_3COOH)	718±444	970±101	968±105
TCOD (mg/L)	5,430±2,046	5,958±488	5,634±481
SS (mg/L)	501±330	536±30	538±24
SO_4^{2-} (mg/L)	1,819±483	1,799±363	1,778±378

Fig. 2. COD removal efficiencies of ARB-NaOH and ABR-Ash treating concentrated rubber latex wastewater under different HRTs and effluent recycle ratios.



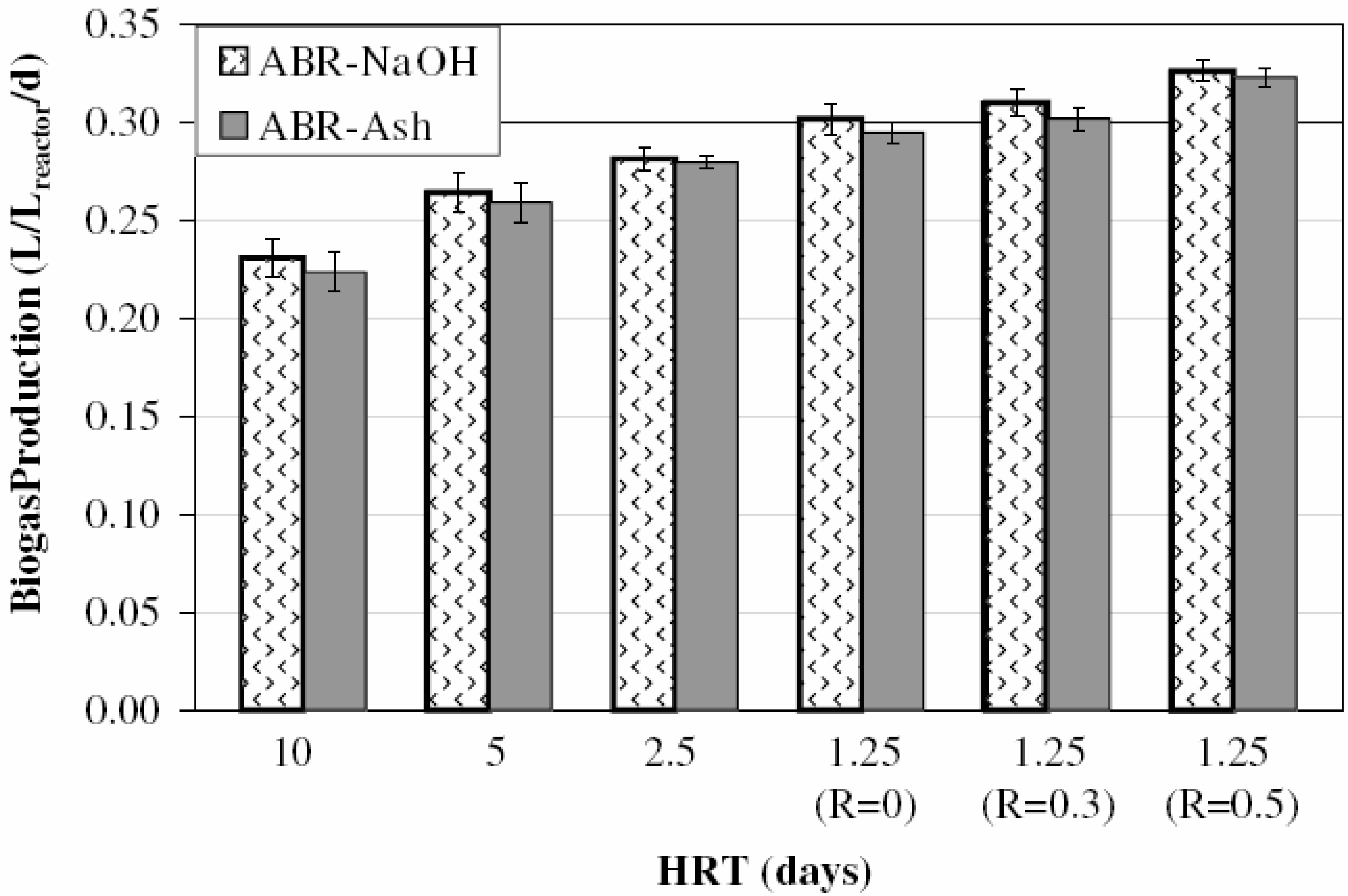


Fig. 3. Biogas production from ABR-NaOH and ABR-Ash treating concentrated rubber latex wastewater at stable condition under different HRTs and effluent recycle ratios.

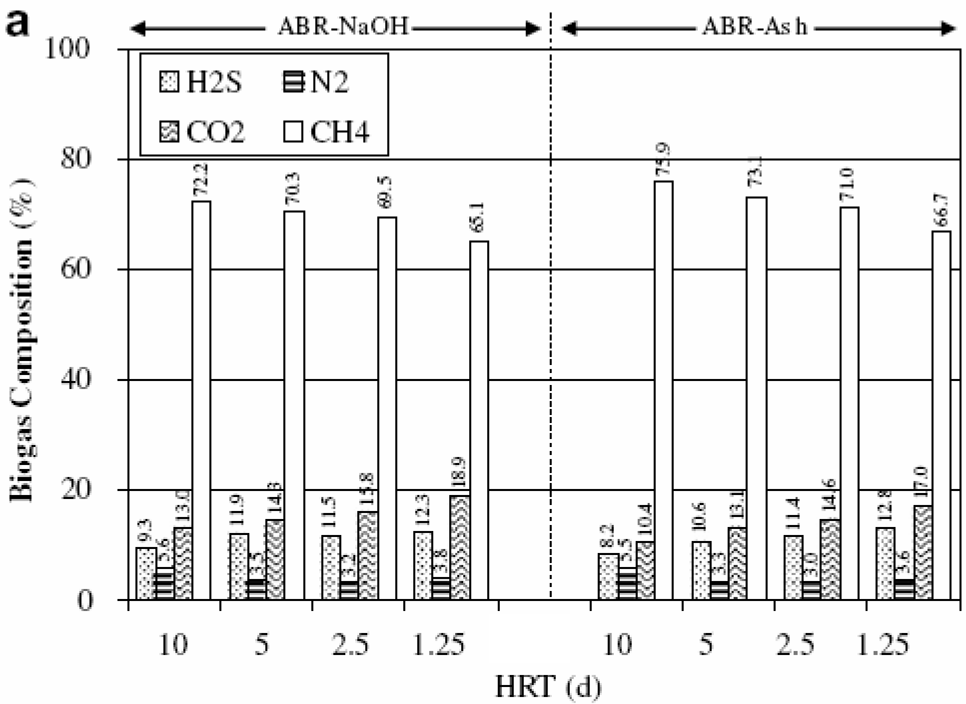
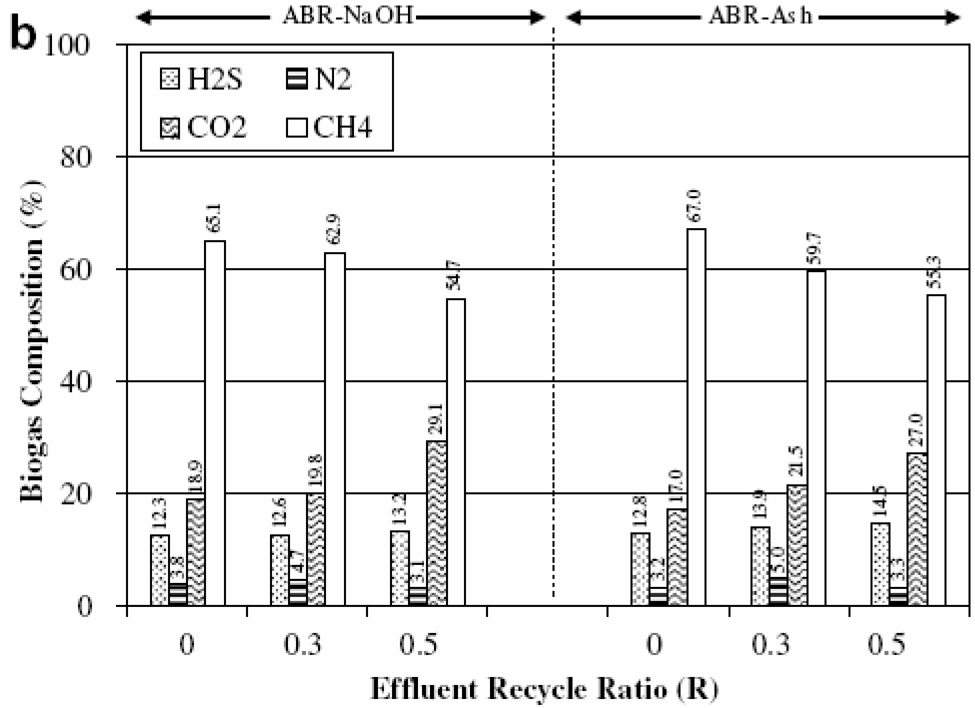


Fig. 4. Biogas composition of ABR-NaOH and ABR-Ash under different HRTs at stable condition (a) without effluent recycle and (b) with effluent recycle.



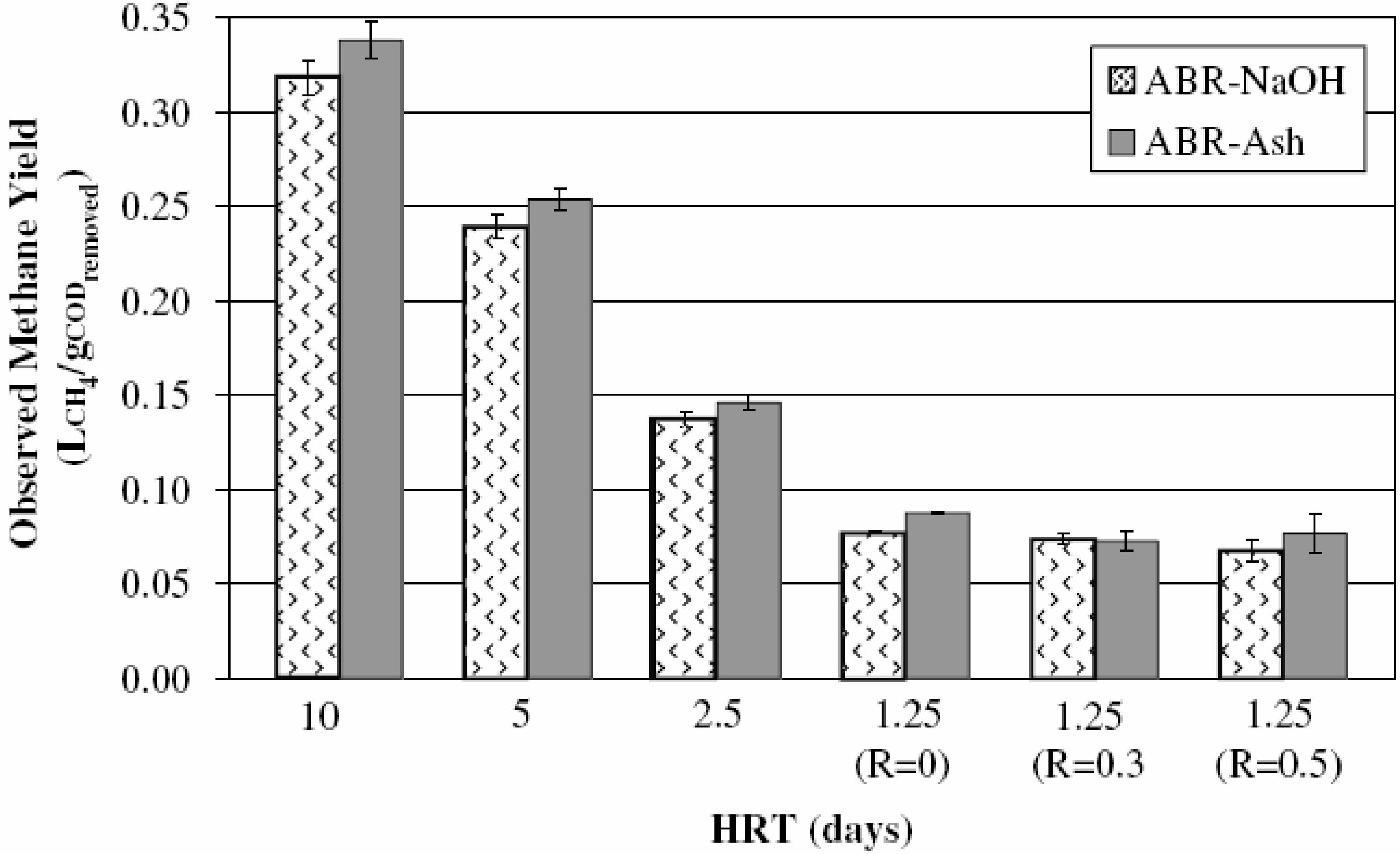
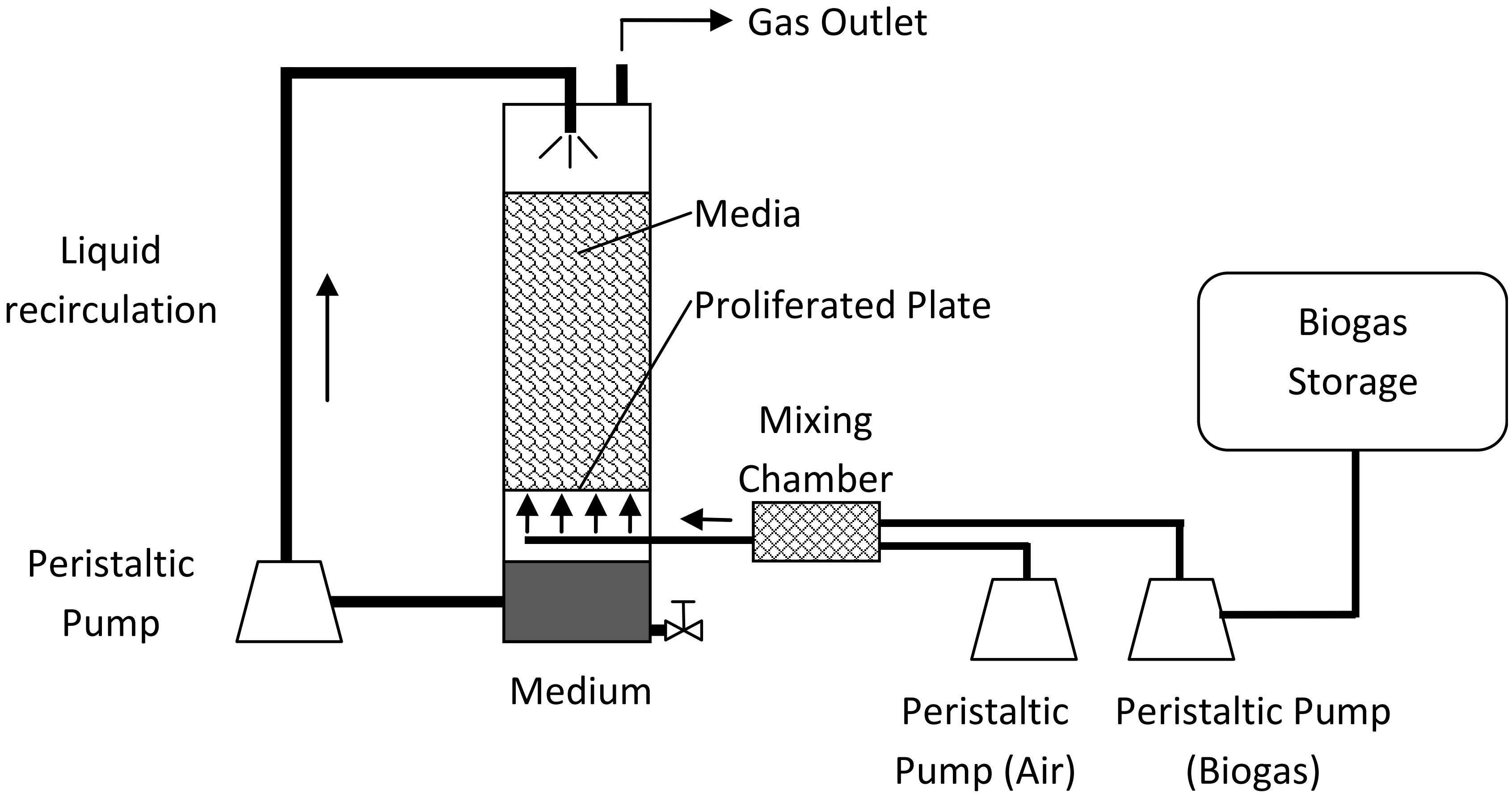


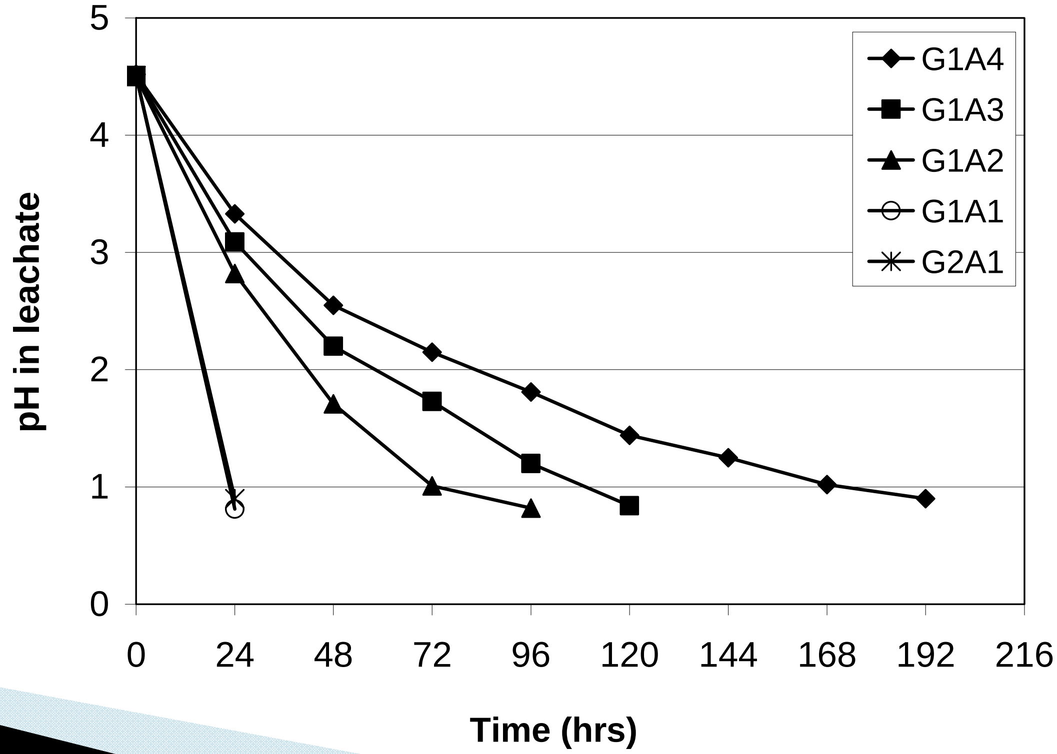
Fig. 5. The observed methane yield of ABR-NaOH and ABR-Ash at stable condition (a) without effluent recycle and (b) with effluent recycle.

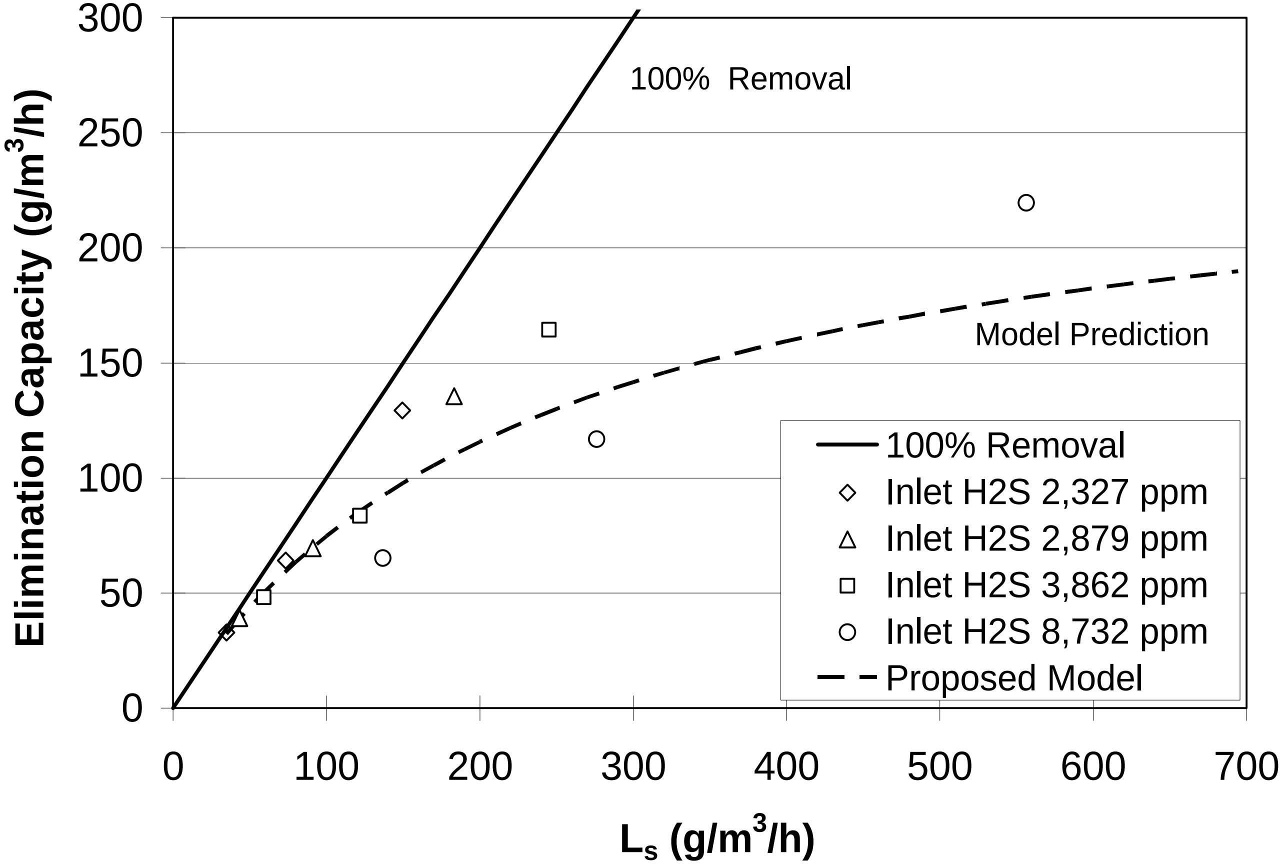
2. Biofiltration of H_2S



H_2S concentration in the gas mixture inlet fed to the biofilters

Biogas-to-Air Ratio	H_2S Concentration (ppmv)
1:4, (G1A4)	2,327±98
1:3, (G1A3)	2,879±94
1:2, (G1A2)	3,862±91
1:1, (G1A1)	8,732±104
2:1, (G2A1)	11,196±371



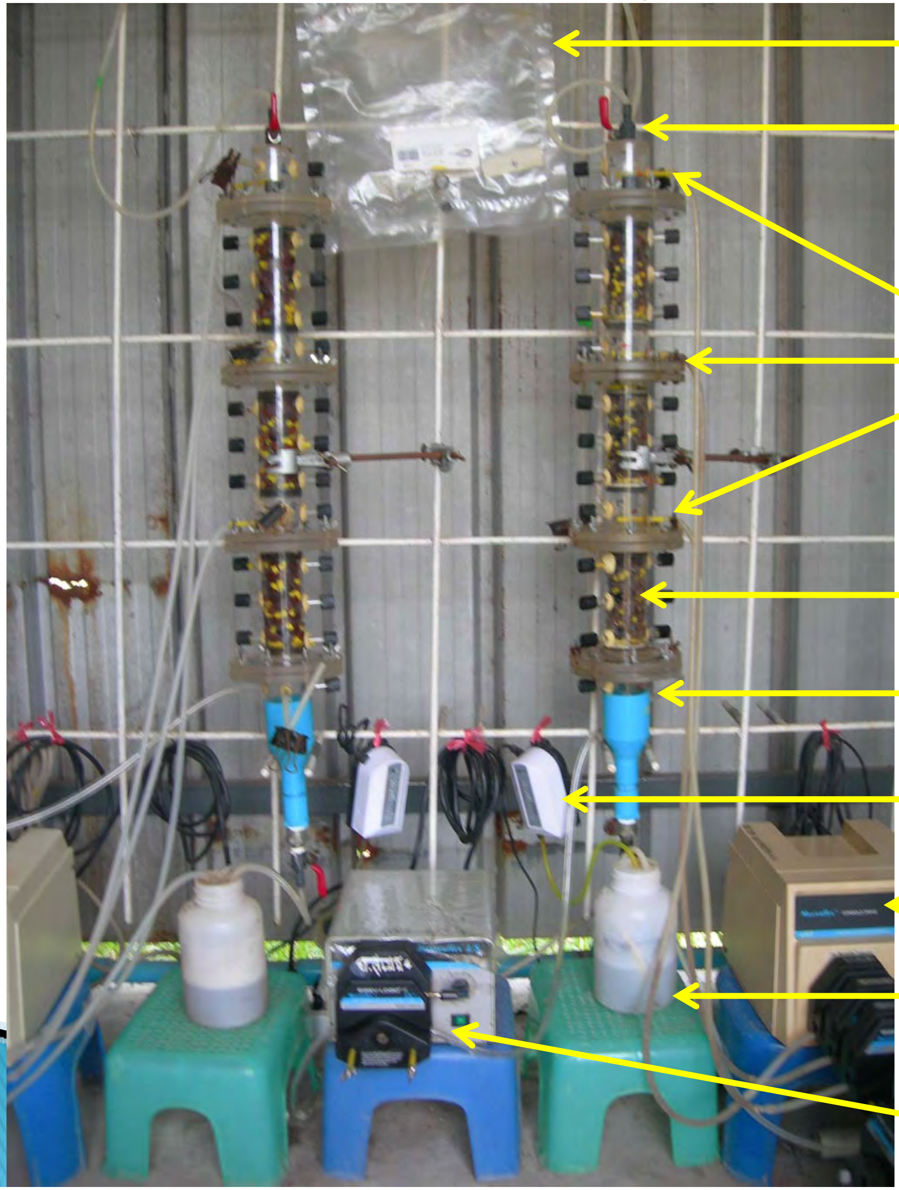


Elimination Capacity (g/m3/h)
300
250
200
150
100
50
0
0
100
200
300
400
500
600
700
Ls (g/m3/h)
100% Removal
Model Prediction
100% Removal
Inlet H2S 2,327 ppm
Inlet H2S 2,879 ppm
Inlet H2S 3,862 ppm
Inlet H2S 8,732 ppm
Proposed Model

Performance of the biofilters receiving synthetic liquid (BF_{SYN}) and serum wastewater (BF_{SE}) as a recirculation liquid under void space retention time (RT) 40 sec. and biogas-to-air ratio G1A4

Gas composition	Biofilter	
	BF_{SYN}	BF_{SE}
H_2S in inlet gas (ppm)	2,234.8±91.4	2,234.8±91.4
H_2S in outlet gas (ppm)	378.5±96.8	397.8±92.1
H_2S inlet loading (g/m^3/d)	141.7±4.7	138.9±5.5
H_2S Removal (%)	83.3±4.4	81.9±3.5
Elimination capacity (g/m^3/d)	117.4±8.2	113.5±9.7
CH_4 in inlet gas (% v/v)	14.6±1.3	14.4±1.0
CH_4 in outlet gas (% v/v)	11.1±1.0	8.0±1.5

Subsequent Research
Biofilter with 3 layers

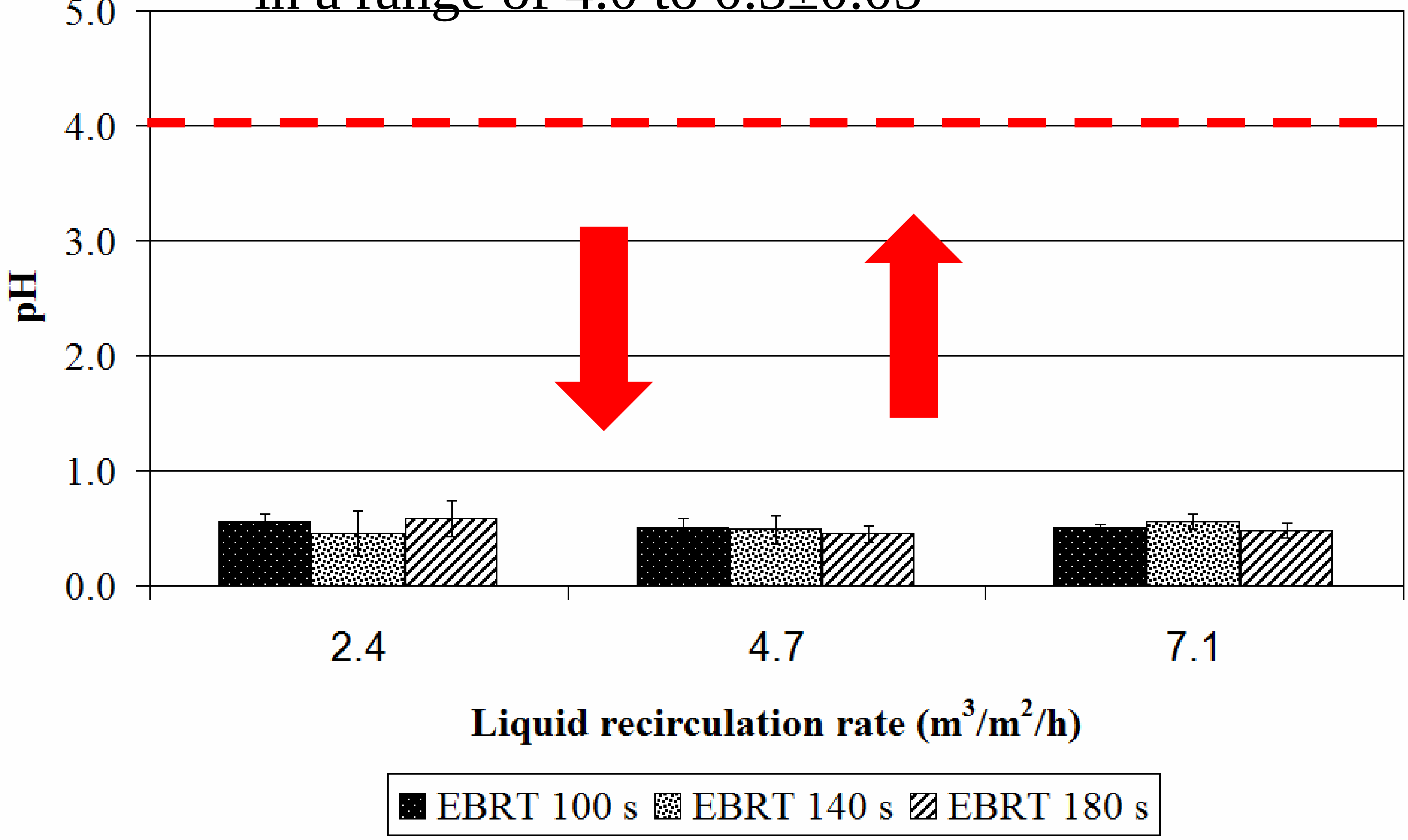


Experimental Design (Biofiltration)

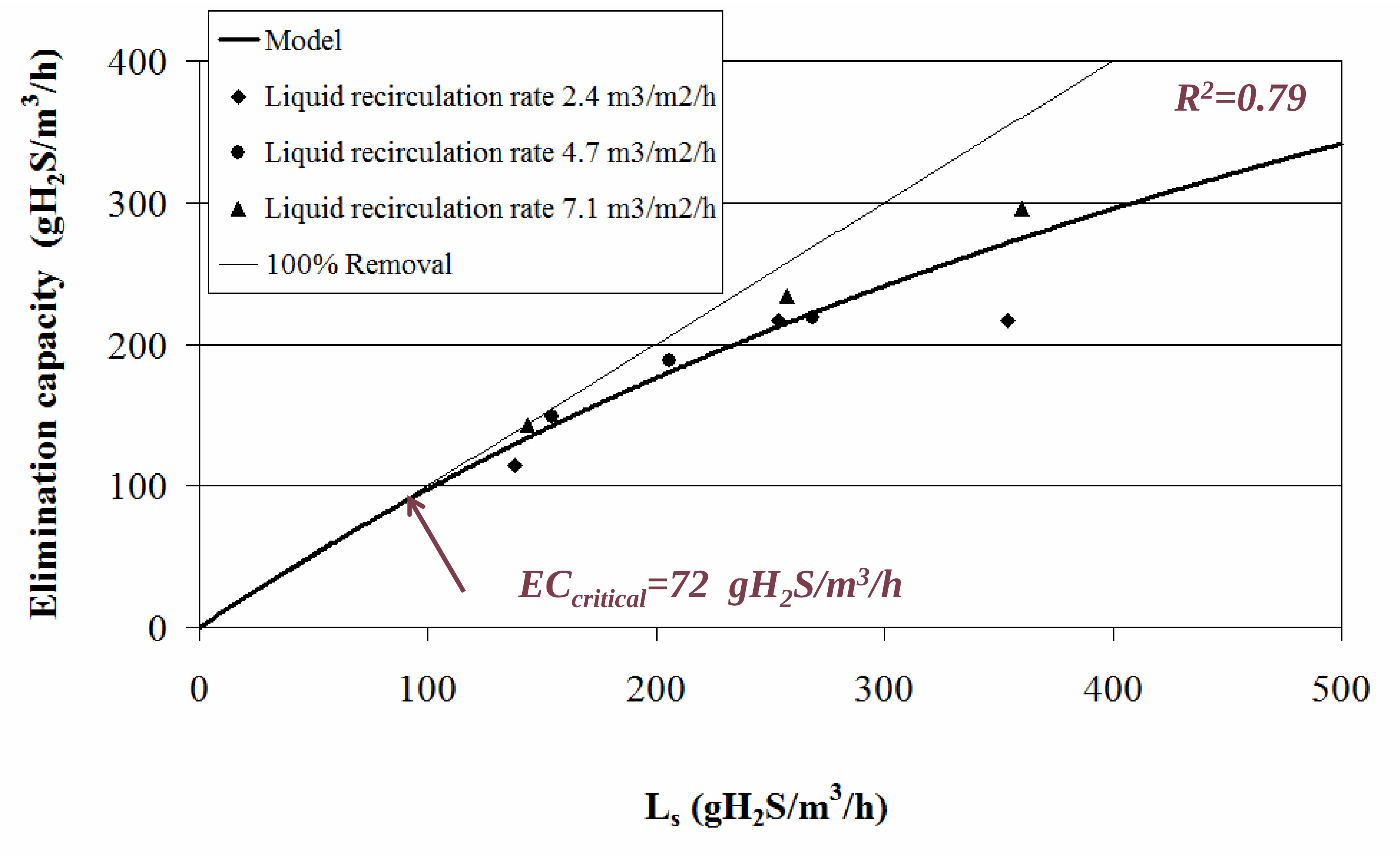
Treatment	EBRT (s)	Liquid recirculation rate ($m^3/m^2/h$)
1	100	2.4
2	100	4.7
3	100	7.1
4	140	2.4
5	140	4.7
6	140	7.1
7	180	2.4
8	180	4.7
9	180	7.1

pH

pH of recirculation liquid was maintained in a range of 4.0 to 0.5±0.05



Elimination Capacity (EC)



Palm Oil Mill

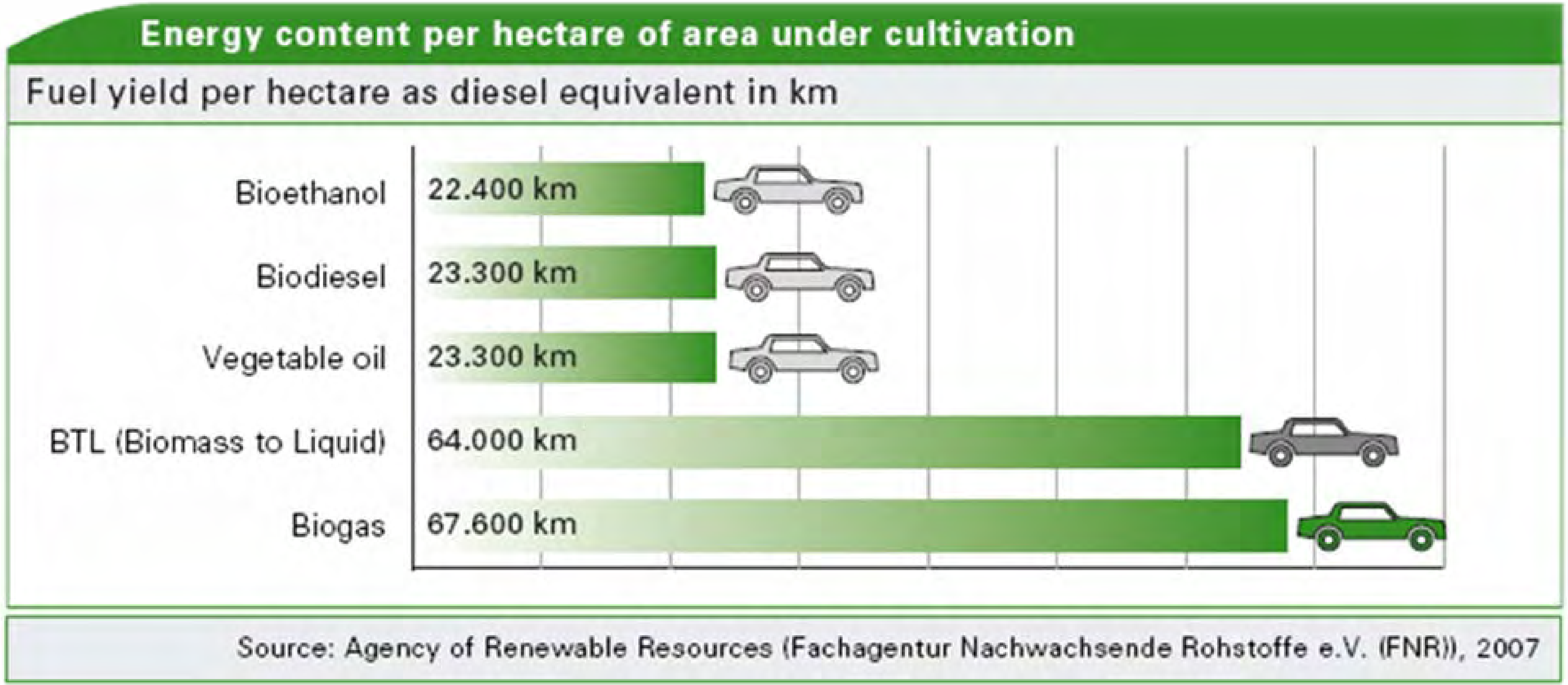
- High strength wastewater
- High in FOG
- Color is difficult to remove
- Residues (fronts, trunk, fiber, shell, and EFB)

Research for palm oil industry

- Temperature phased AD
- Bio-chemical pretreatment of palm oil residues for biogas production
- Co-digestion on palm oil residue with high N waste
  - Pig farm
  - Concentrated latex factory
- Formulation of carbon emission from palm oil industry

Emergent opportunity

- Co-digestion
  - Solids mix to liquid or liquid to liquid
  - Nutrient balance vs economic values vs food shortage
  - High solid digestion
  - Dry fermentation
- Other materials
  - Wastes after harvest (plant residues)
  - Fast growing plants
  - Food waste
  - Municipal solid waste (organic fraction)



Energy content per hectare of area under cultivation
Fuel yield per hectare as diesel equivalent in km
Bioethanol
22.400 km
Biodiesel
23.300 km
Vegetable oil
23.300 km
BTL (Biomass to Liquid)
64.000 km
Biogas
67.600 km
Source: Agency of Renewable Resources (Fachagentur Nachwachsende Rohstoffe e.V. (FNR)), 2007

http://www.tufts.edu/tuftsrecycles/more/USstats.html